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EFFECT OF MOISTURE CONTENT ON THE STABILITY OF A YELLOW CAKE MIX COMPOUNDED WITH PLASTIC AND POWDERED SHORTENINGS[1]

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ABSTRACT

Prepared cake mixes for use by the Armed Forces must be capable of withstanding prolonged storage under the adverse conditions frequently encountered in overseas supply channels. To determine the role of moisture in deterioration of yellow cake mix, a series of cake mixes were compounded with an undehydrated flour (11.7% moisture) and the same flour was dehydrated to three moisture contents (8.0, 2.8, and 2.1% respectively), a plastic shortening and two types of commercially available powdered shortening products being used, respectively. The mix samples were stored in hermetically sealed containers at 100°F. (37.8°C.). Representative portions were test-baked at monthly intervals and free fatty acid content and peroxide values were determined on fat extracted from the samples at bimonthly intervals. Cake mixes compounded with flour of normal moisture content (11.7%) deteriorated in 4 to 6 months, whereas those containing 8.0% moisture flour deteriorated in 7 to 8 months. Mixes compounded with flours containing 2.8% moisture or less performed satisfactorily after one year's storage. Cake mixes compounded with flours having normal (11.7%) and 8.0% moisture and powdered shortening were more stable than mixes compounded with identical flours and plastic shortening. The rate of free fatty acid development in mixes compounded with 8.0% moisture flour was significantly lower than in mixes compounded with flour at normal moisture content (11.7%). Development of free fatty acid in mixes compounded with flours containing 2.8% moisture or less was arrested. Peroxide values showed no correlation with storage deterioration.

Prepared cake mixes are advantageous to military feeding operations because they assure production of uniformly acceptable baked items, simplify logistical problems, and reduce requirements as to baking skill and equipment. In military overseas supply channels, food products are frequently held for long periods and stored under adverse conditions of temperature and humidity. Prepared cake mixes that are commercially available cannot withstand these rigorous and protracted storage conditions. Consequently, a development project was undertaken by the Quartermaster Food and Container Institute to investigate new ingredients and evolve methods for increasing the storage tolerance of prepared cake mixes.

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In conjunction with the Quartermaster Food and Container Institute development program, a study sponsored by the Department of Defense was conducted by the University of Minnesota to determine the moisture equilibria of the various prepared mix ingredients and mixes (6). Data obtained in this study indicated that deteriorative chemical changes, primarily in leavening chemicals, occurred less rapidly at lower moisture contents. These observations led to the consideration of the role of moisture in the deterioration of prepared cake mixes and of possible methods of reducing moisture content in prepared cake mixes. Since the flour employed in cake mixes is the principal moisture-bearing ingredient, it obviously followed that flour dehydration would facilitate preparation of samples of reduced moisture content. Patents issued prior to this work and to other investigators during the course of these studies confirmed the utility of this approach (5, 7, 9).

Initial attempts to dehydrate cake flour by exposure on trays in a hot-air oven were disappointing. When soft-wheat cake flour was dehydrated below 8% moisture by these means, the baking properties of the flour were severely damaged by heat. Arrangements were made with the Institute of Industrial Research, University of Denver, to dehydrate a sample of soft-wheat cake flour using a "flash" dehydration system which had been effective in post-drying powdered egg products. A preliminary exploratory drying experiment demonstrated that soft-wheat flour could be dehydrated to 3.0% moisture without any evidence of heat damage to the baking properties of the flour.

Preliminary and exploratory stability studies upon prepared cake mixes suggested that such mixes, compounded with commercially available powdered shortening products, displayed greater storage tolerance than identical mixes compounded with plastic shortening. To explore more thoroughly the possibility of increasing the stability of cake mixes by use of these products, two types of commercially available powdered shortening were used in the experiments. This paper presents data of test-baking studies and analyses of free fatty acid of prepared yellow cake mixes compounded with one cake flour at four different moisture contents and a plastic shortening and two types of commercial powdered shortening, after various intervals of storage at 100°F.

Materials and Methods

Ingredients Employed. The bleached soft-wheat cake flour employed in compounding the yellow cake mixes analyzed 11.7% moisture, 7.8% protein (N $\times$ 5.7), and 0.32% ash calculated on a 14%

moisture basis. A portion of this flour sample was used as the undehydrated control flour and the remainder of the sample was used in the "flash" dehydration experiments at the University of Denver. A schematic sketch of the "flash" dehydration system used to dry these flour samples is shown in Fig. 1.

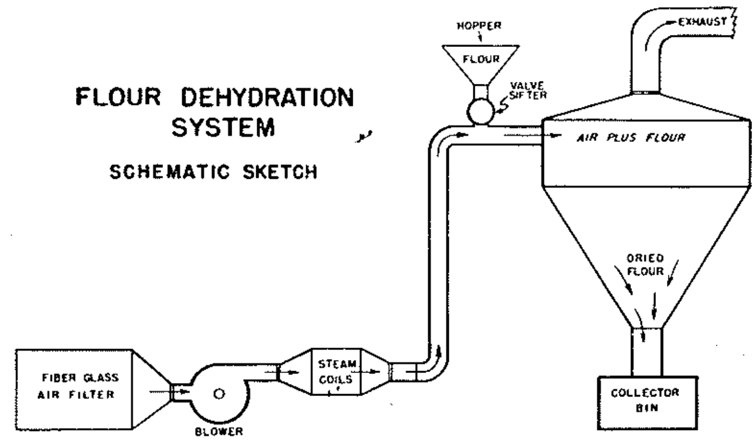

Fig. 1. Schematic diagram of flash dehydration system employed for drying flour.

In the operation of the system, incoming air is first filtered to remove air-borne foreign material and is then passed through the blower and over steam-heated coils. The flour to be dried is fed from the hopper through a sifter air-lock valve into the heated air stream. The mixture of flour and heated air then enters the cyclone collector. The dehydrated flour is discharged at the foot of the cyclone, and the moisture-laden air is exhausted at the top of the collector.

Dehydration runs were made to yield a series of three flour samples of dehydrated soft-wheat flours of various moisture contents. Seventy-five pounds of flour was dried for each sample. The operating conditions of the "flash" drier and the final flour moisture contents are shown in Table I.

Since the optimum drying conditions for flour and the operating limits of the system were unknown, the final moisture contents of the dehydrated flours could not be predicted. Undoubtedly, it would have been more desirable to have the moisture contents of the dehydrated flours more evenly spaced. Critical test-baking of the dehydrated flour samples in angel food and high-sugar layer cakes (140%) failed to show any evidence of heat damage to the flour.

TABLE I

FLOUR DRYING CONDITIONS

Sample Number	Number of Passes	Air-Stream Temperature	Flour Temperature When Collected	Final Moisture Content
				%
1	1	210°F.	136°F.	8.0
2	1	236°F.	157°F.	2.8
3	2	248°F.	178°F.	2.1

The shortening and shortening agents used in compounding the prepared cake mixes are defined as follows:

1. *Plastic Shortening.* The plastic shortening was composed of hydrogenated cottonseed and peanut oils displaying an A. O. M. keeping test in excess of 100 hours (2). Antioxidants were not used.

2. *Type I Powdered Shortening.* The Type I powdered shortening was manufactured by spray-drying a homogenized mixture of hydrogenated shortening (of the same composition as the plastic shortening), fluid skim milk, and sucrose. The composition of the dried shortening product was 73% shortening, 23.5% milk solids nonfat, 2% sucrose, and 1.5% moisture.

3. *Type II Powdered Shortening.* The Type II powdered shortening was manufactured by spray-drying a homogenized mixture of hydrogenated shortening (of the same composition as the plastic shortening), liquid egg yolks, fluid skim milk, and sucrose. The composition of the dried shortening product was 60% shortening, 18% egg yolk solids, 18% milk solids nonfat, 2% sucrose, and 2% moisture.

The powdered egg solids used in the cake mix formulation were not fermented and contained not more than 4% moisture. The powdered milk solids nonfat used were Premium Grade Spray Dried as defined by the Standards of the American Dry Milk Institute (1).

Cake Mix Formulation, Sample Preparation, and Storage. The formulas employed in compounding the prepared yellow cake mixes for the storage studies are illustrated in Table II.

A yellow cake mix was selected for the storage studies because it contained the fewest ingredients, and no flavoring ingredients which might mask off-flavors developed during storage. The three mix formulas were so balanced that the ratios of shortening, egg yolk solids, and milk solids nonfat were essentially the same for each formula. Each formula was compounded with an undehydrated control flour and the three dehydrated flours containing 8.0, 2.8, and 2.1% moisture respectively. In the prepared cake mixes compounded with the dehydrated flours, adjustments were made to compensate for the reduced moisture content of the flour. Thus, the flour solids were held constant in each mix formula.

TABLE II

YELLOW CAKE MIX FORMULAS

Ingredients	Formula 1	Formula 2	Formula 3
Granulated sugar (Baker's Special)	39.25	39.25	39.25
Plastic shortening	12.85	....	....
Egg-yolk solids	3.70	3.70	....
Milk solids nonfat	3.70	....	....
Type I powdered shortening	....	16.55	....
Type II powdered shortening	....	....	20.25
Sodium bicarbonate	0.55	0.55	0.55
Mono-calcium phosphate	0.37	0.37	0.37
Sodium acid pyrophosphate	0.37	0.37	0.37
Salt	1.00	1.00	1.00
Soft-wheat flour	38.21	38.21	38.21
Total	100.00	100.00	100.00

Moisture analyses of the prepared cake mixes were made by the official A.O.A.C. vacuum-oven method (4). The relationships of flour moisture content to that of prepared mix are shown in Table III.

TABLE III

MOISTURE CONTENTS OF BLENDED CAKE MIXES

Flour Moisture Percentage	Nature of Shortening		
	Plastic	Type I Powdered	Type II Powdered
Control, undehydrated	4.3	4.4	4.3
8.0	3.3	3.1	3.0
2.8	1.2	1.4	1.2
2.1	0.9	1.0	0.9

Immediately after blending, 20-oz. portions of each mix were hermetically sealed in No. 2½ cans and stored in a constant-temperature room operated at 100°F. ± 2°.

Test-Baking and Analytical Methods. Samples were withdrawn from storage at monthly intervals for test-baking and moisture analyses. At bimonthly intervals free fatty acid content and peroxide values were determined upon fat extracted from the stored mixes.

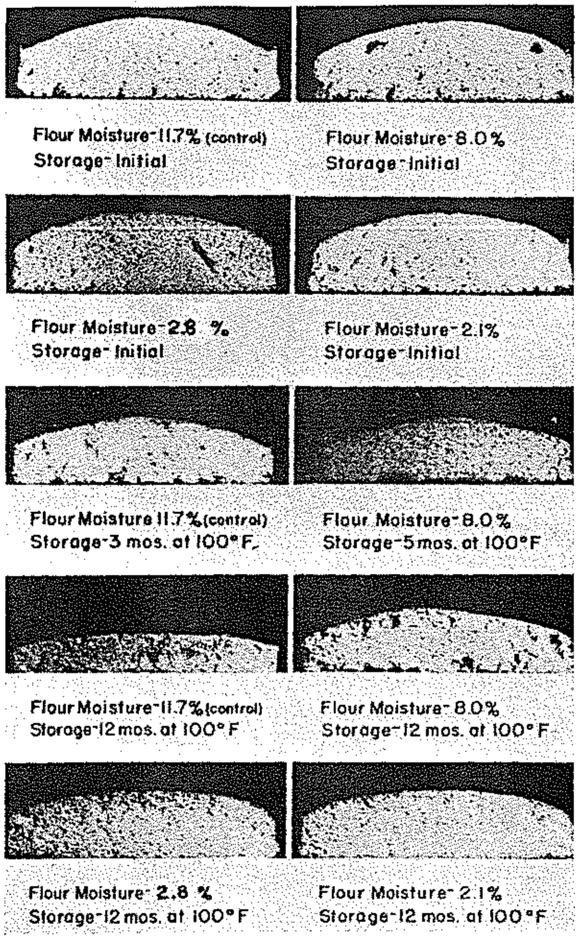

Fig. 2. Photograph of cakes baked from mixes made with plastic shortening, after storage for different periods.

For these determinations, the fat was extracted from the mix with chloroform at room temperature, using four successive extractions with 5 minutes of mechanical shaking for each extraction. The chloroform extracts were filtered through No. 12 Whatman filter paper, the filtrates combined and made up to a predetermined volume. Free fatty acid content (3) and peroxide values (8) were determined upon duplicate aliquots.

Cake batters for test baking were prepared, using 1 lb. mix and

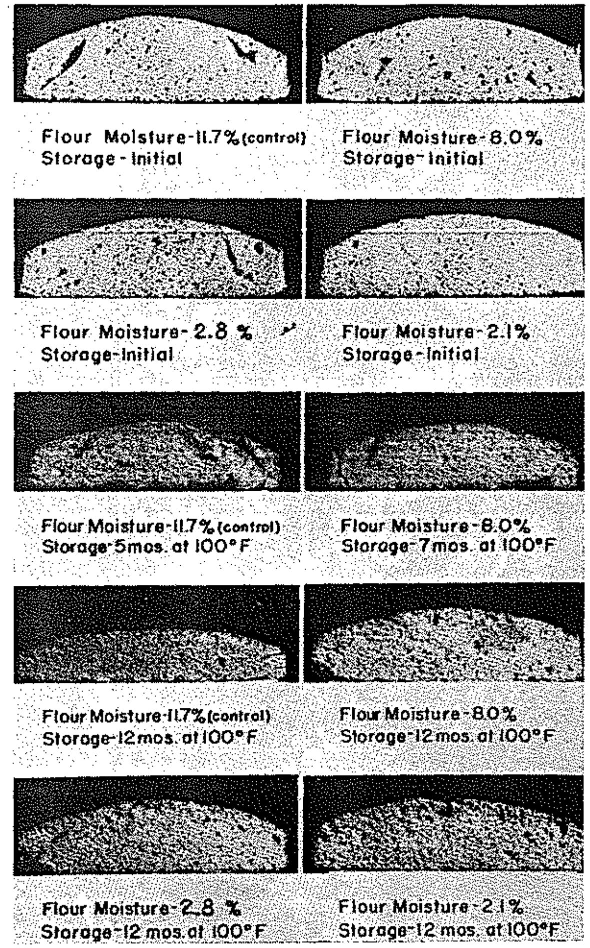

Fig. 3. Photograph of cakes baked from mixes made with powdered shortening (Type I), after storage for different periods. Type I powdered shortening contained 73 percent shortening, 23.5 percent milk solids nonfat, 2 percent sucrose, and 1.5 percent moisture.

8 oz. cold water. Adjustments were made in the batter recipe for those mixes compounded with dehydrated flours so that the moisture contents of the batter were held constant. Water was added in a three-stage procedure (50-25-25%). The batters were mixed in a 3-qt. bowl with flat paddle on a Hobart C-10 mixer in a standardized procedure on low speed. Two hundred and fifty grams of batter was baked in each of two 5-in. round layer tins at 350°F. for 25 minutes. After cool-

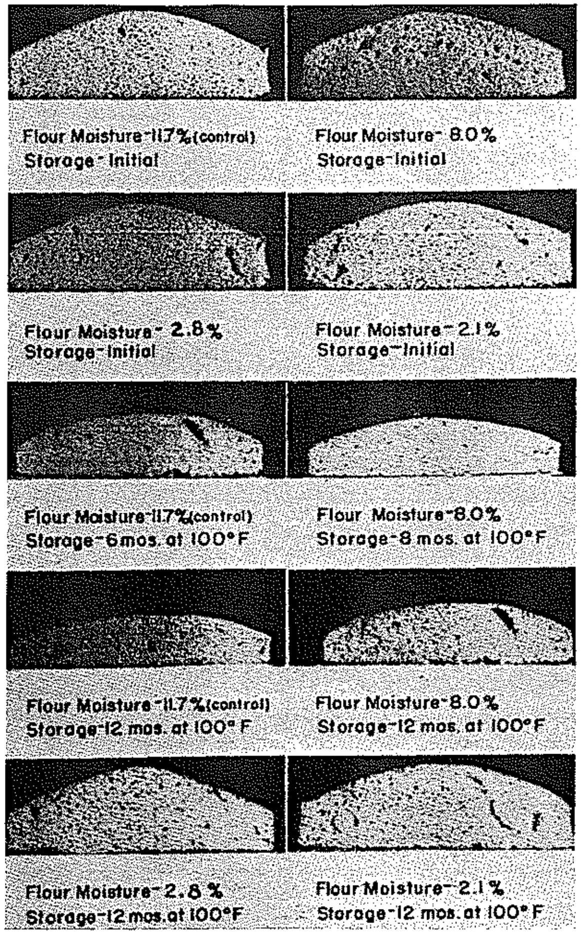

Fig. 4. Photograph of cakes baked from mixes made with powdered shortening (Type II), after storage for different periods. Type II powdered shortening contained 60 percent shortening, 18 percent egg-yolk solids, 18 percent milk solids nonfat, 2 percent sucrose, and 2 percent moisture.

ing to room temperature, cake volumes were measured by rape seed displacement.

Results and Discussion

Figures 2, 3, and 4 are photographs of cakes baked from the storage samples of prepared cake mix. The horizontal center row in each illustration shows cakes at the time they fell below the arbitrarily

established minimum levels in cake volume. Storage deterioration in the baked cake is characterized by loss of cake volume, indistinct grain structure, excessively tender and gummy texture, crumb discoloration, and objectionable off-flavor and aromas. The open-grain structure of the cakes compounded with powdered shortening (Figs. 3 and 4) is attributable to the poorer baking properties of the powdered shortening products used in this work.

The relationship of storage time to the specific volume (cake volume in cubic centimeters divided by cake weight in grams) of cakes baked from the stored mixes is shown in Fig. 5, which consists of three graphs arranged according to the shortening or shortening agent employed. The horizontal bars at specific volume 2.25 indicate the arbitrarily established minimum acceptable specific volume.

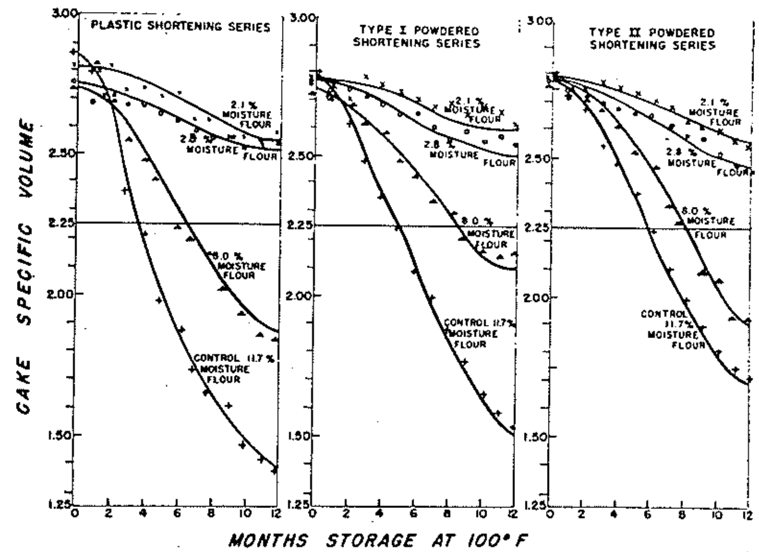

Fig. 5. The relation of storage time to the specific volume of cakes baked from prepared mixes compounded with flour of different moisture contents and with three types of shortening.

The rates at which free fatty acids develop in the prepared cake mixes during storage are shown in Fig. 6.

Peroxide values determined upon the chloroform-extracted fat from the stored mixes showed no increase in the majority of the analyses. In those few instances where increases were indicated, no correlation with storage time was apparent. The aromas of the stored mixes and cakes baked from the mixes were not characteristic of oxidative rancidity in any instance.

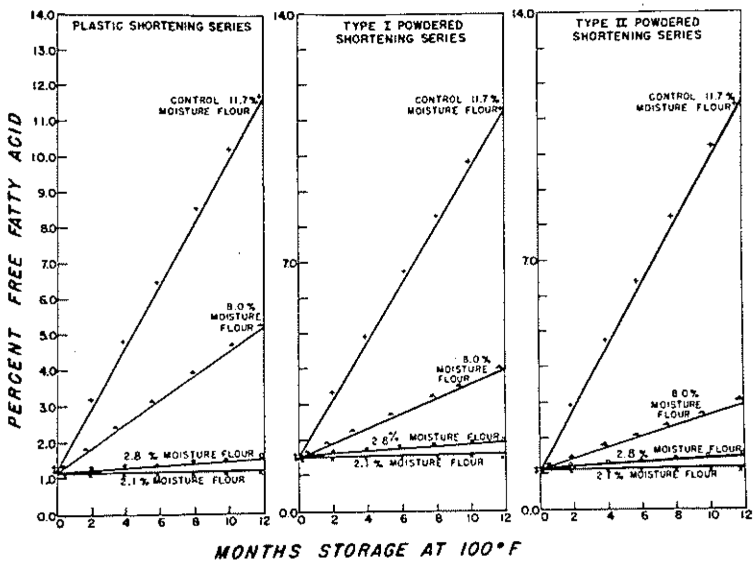

Fig. 6. The rate of development of free fatty acids in cake mixes prepared with flour at different moisture contents and with the three types of shortening.

Specific volumes (Fig. 5) of cakes baked from the storage samples declined most rapidly and to the greatest degree in mixes compounded with the undehydrated flours. The decline was less rapid in the undehydrated flour mixes compounded with the powdered shortening agents, and least rapid in the mixes compounded with the Type II powdered shortening. In the mixes compounded with flour at 8% moisture, the rate and degree of decline in specific volume was substantially reduced. In this flour series, the mix made with Type I powdered shortening proved to be the most stable. No explanation can be offered for this apparent inconsistency. In those cake mixes compounded with flours dried to 2.8 and 2.1% moisture, respectively, there was a slight decline in cake specific volume over the 12-month storage period. However, these cake specific volumes all remained well above the arbitrarily established limits for cake volume throughout the storage period. At what time these mixes would have fallen into the unacceptable range must remain a matter of speculation.

Development of free fatty acid (Fig. 6) proved to be a straight-line function of time of storage. In the mixes compounded with the undehydrated flour, free fatty acids developed at a constant rate regardless of the shortening or shortening agent employed. However, in the mixes compounded with the flour containing 8% moisture, differences

in the rate of development of free fatty acid did appear; development was most rapid in the plastic shortening mix and least rapid in the Type II powdered shortening mix, and in those mixes compounded with the flours at 2.8 and 2.1% moisture it proceeded at an extremely low rate or was arrested entirely.

The high free fatty acid content of cake mixes of deteriorated baking properties certainly suggests that development of free fatty acid is associated with deterioration. While development of free fatty acid parallels deterioration of cake mix in most instances in these experiments, a direct correlation between free fatty acid content and degree of cake mix deterioration is not apparent. Moreover, in these experiments it is uncertain whether the fat splitting is the result of lipase activity or chemical hydrolysis.

These experiments demonstrate that the use of dehydrated cake flour is an effective means of extending the storage life of prepared cake mixes. Information is lacking, however, on the stability of prepared cake mixes compounded with cake flours ranging in moisture content from 8.0 down to 2.8%. Experiments to provide this information are in progress.

Acknowledgments

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